High Quality Frozen Seafoods: The Need and the Potential in the United States

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Introduction

The passage of the Fishery Conservation and Management Act of 1976, which brings relatively rich fishing areas within the newly established 200-mile jurisdictional boundary off U.S. coasts, makes possible larger catches for U.S. fishing vessels. And, since the overall harvesting pressure will be markedly reduced due to reduction in foreign fishing, replenishment of important species such as haddock will eventually result in the availability of even more fish to catch. Thus, there is the potential for the United States to once again become one of the top fishing nations of the world—a desirable position for this country.

Increased landings would reduce this nation's heavy dependence on imports, making it less vulnerable to the vagaries of international competition for edible goods. Increased landings would also tend to improve our position in international trade, especially if we could catch enough fish to not only satisfy the bulk of our demand but to increase our exports significantly. This would, of course, be associated with an increase in processing effort and corresponding increases in ancillary business activities.

Even though it may be too soon to expect any sizeable increase in the fish stocks, evidence of an impending seafood bonanza is reflected in an unusual increase in harvesting capacity and a burgeoning interest in the various elements of the seafood industry.

The potential for increased seafood harvests goes beyond the simple economics of increasing the domestic output. It could account for a significant increase in the per capita consumption of seafoods in this country (per capita consumption equals the total number of pounds of seafoods consumed in 1 year divided by the total population). In the United States this is about 12.5 pounds, and it has not changed much in decades, despite the fact that fish offer unique nutritional and perhaps therapeutic advantages as protein foods. Thus, increased domestic landings might result in a higher per capita consumption which would benefit the health of consumers as some of the meat in the diet became replaced with fish and fish products, especially those that are low in fat.

To get some perspective of the quantity of the increased landings that is possible, it should be noted that foreign vessels harvested an estimated 3.7 billion pounds of fish during 1977 in the U.S. fishery conservation zone (within the 200-mile limit). While it is not practical to anticipate that the United States could actually increase its landings by that much, certainly there is no reason why U.S. fishermen could not gear up to catch the bulk of that amount.

In the United States, fish are largely consumed as fresh, frozen, canned, and cured. Should the per capita consumption increase, it is believed that the bulk of the added consumption would be in the form of frozen products, even though it is expected that there would be a sizeable increase in the consumption of fresh products. Currently there are indications of increased sales of fresh fish in various parts of the country, especially where attempts are made to control the quality of the products. While the growth is largely in coastal areas, the use of air transportation has made possible the delivery of high-quality fresh seafoods to inland areas. Indications are that quality is so important to consumers that they are willing to pay the added costs that are incurred to maintain quality. The added costs include those for inspection, prepackaging, proper refrigeration, and special handling. As a matter of fact, it has been speculated that the outstanding

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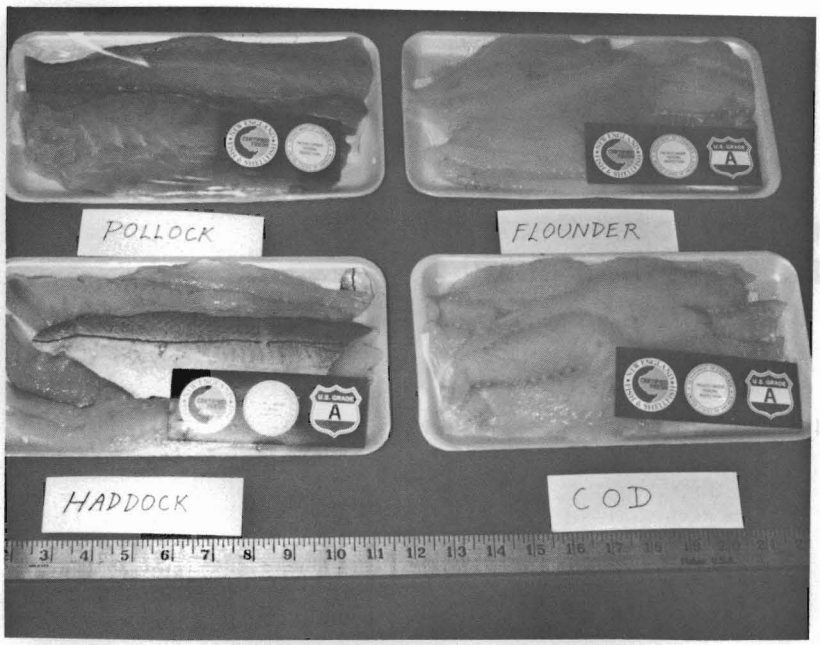


Prepackaged U.S. Grade A fish fillets.

reason for the low per capita consumption of fish in the United States is the unreliability of its quality at point of sale. A recently completed 2-year study by the National Marine Fisheries Service demonstrated that when quality was assured to be U.S. Grade A at point of sale, there was a measurable increase in sales, up to 20 percent (Ronsivalli et al., 1978). However, the distribution of fresh fish is associated with losses due to spoilage, limited distribution due to the short shelf life of the product, mishandling due to laxity, large fluctuation in price due to the sharp shifts in the supply-to-demand ratio, and unreliability of supply due to the variety of reasons why fish are sometimes not landed in sufficient amounts. (Many vessels either do not go to sea or, if at sea, cannot harvest fish effectively during stormy weather, adequate catches are not always made, malfunction of gear, accident, etc.)

The logical disposition of additional landings would be to preserve them by freezing as fillets, fillet blocks, whole fish, steaks, and prepared products. In the first place, preserving fish by freezing keeps them at near initial quality when they are properly handled, packaged, and stored. Also frozen products can be held for quite long periods (more that 1 year). Thus, large landings could be frozen and stored. (Otherwise, in many cases large landings currently command a relatively low price per pound. On the other hand, prices make a sharp rise when landings are low.) By freezing fish during times of glut, the supply during lean times could be assured, and this would result in stabilization of both the prices at retail and the reliability of supply all year round for the consumer, the institutional user, and the processor. When fish are properly frozen and properly handled, the long storage life that results permits distribution anywhere in the world, provided that the transportation vehicle is capable of providing the necessary refrigeration capacity. The economic potential for handling fish in the frozen form is evidenced by the fact that fast-food chains use only frozen fish for their fish sandwiches, the high quality of which is indicated by the strong sales growth of this commodity. Also, the notion that frozen fish is not as good as fresh fish in quality is not supported when one compares the quality of fish in the fast-food chain sandwiches with the quality of fresh fish. The facts are that the frozen fish that become fish sandwiches in fast-food chains are of high initial quality, and are properly frozen and handled, whereas frozen fish that are eventually sold in the retail cases of supermarkets are of variable quality initially and maybe frozen and handled in less than satisfactory fashion. This can result in products that may be rancid, tough, dehydrated, and generally unacceptable.

What is Needed

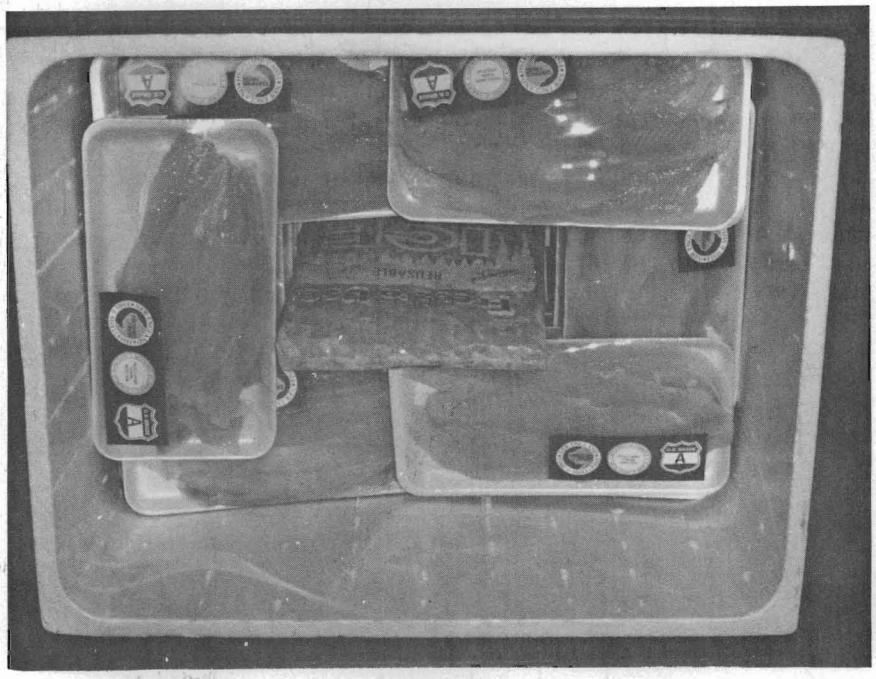
For more than a decade the Consumers Union[1] and other consumer groups have published articles condemning the quality of fishery products that are available to the consumer. In one article (Anonymous, 1961), the religious connotation of fish as a penance food is attributed to the image of poor quality with which it has long been associated. A recent study (Ronsivalli et al., 1978) has demonstrated beyond doubt the customer satisfaction and demand gained by controlling the quality of the product. While freezing is theoretically the preferred method for preserving fish, certain changes in attitude and procedures will have to occur in the way fish are harvested, processed, packaged, transported, stored, and displayed at retail if we are to produce high quality frozen fish.

Temperature Control

The shelf life of fresh fish at 32° F is about 2 weeks. Its quality remains at Grade A for about 1 week. Both the shelf life and the time during which the product remains at Grade A are shortened as the holding temperature is increased. Thus, since much of the U.S. catch is landed unfrozen, it can be seen that the length of time and the tem-

[1]Reference to commercial firms or groups does not imply endorsement by the National Marine Fisheries Service, NOAA.

perature at which fish are kept aboard the fishing vessel and elsewhere, until they are frozen, will determine the quality of the product at time of freezing. Aboard the fishing vessel, fish will have to be well iced (Dassow, 1976), preferably in boxes, or they may be held in chilled seawater (Hulme and Baker, 1977), and, at that, they should not be held for longer than 2-3 days. It can be seen from this that whether vessels are bringing in fish that are to be handled as fresh in the distribution chain or as frozen, it appears that they cannot make trips that are longer than 2-3 days, unless (for fish to be sold as frozen) they have the capacity to freeze all fish that might conceivably have to spend more than 2-3 days before they can be processed on land. There is no alternative to these guidelines, which will add to the cost, but the extra cost involved in following them will be returned in enhanced image, less waste of resource through spoilage, satisfied consumers who are willing to absorb the extra cost (Ronsivalli et al., 1978), etc.



Preparing U.S. Grade A fish fillets for shipment.

Whether increased landings are frozen at sea or (as appears most likely for most U.S. vessels) on land, the product must be frozen as soon as possible. It must be packaged so as not to lose moisture nor to be exposed to oxygen, and throughout its distribution and storage, its temperature should not be allowed to exceed 0° F.

Warehouse and Freezing Capacities

To hold frozen products for varying lengths of time, considerable warehouse space will be needed. At present, the processors of marine products do not have capacity to freeze and store large quantities of fish and shellfish. There should, therefore, be a considerable investment in both—whatever equipment may be necessary for the freezing of predictable increased amounts of marine products as well as for the storage of these products at suitable low temperatures. This should enable processors to take care of their needs for further processing as required in the production of such foods as fish sticks and fish portions and also provide for increased retail sales of frozen fish fillets.

Packaging

The packaging of frozen marine products under current practices is almost totally inadequate. Almost all packages used for these foods offer little barrier to moisture loss or to the entry of oxygen. Thus, dehydration occurs, accelerating both rancidification and toughening (denaturation of proteins), and, of course, since these packages allow the diffusion of oxygen, oxidation, which causes rancidification, is further accelerated. Another deficiency of packaging for products such as breaded shrimp is the space within the package that is not occupied by the product. This leads to dehydration of the food, reduced net weight, cavity-ice formation, and deterioration of the quality of the product during frozen storage.

Many packaging materials, including polyesters, polyvinylidene chloride, and aluminum laminates are presently available for frozen foods which will prevent dehydration of the food and the diffusion of oxygen, hence preventing oxidation and rancidification. They also provide for packing the food under a vacuum, hence eliminating empty space within the package and thus the formation of cavity ice. This type of packaging is more expensive than the inadequate ones which are mostly in use today, but, considering the present average cost of fish and shellfish to the consumer, it should be no deterrent to add the price of adequate packaging to seafoods. This is especially the case since, in the long run, the consumer would benefit by receiving a food of much better quality. At present, it is very difficult to buy salmon and mackerel, during winter months, which are not rancid. If packaged properly there is no reason that it should not be possible to obtain good quality salmon steaks and mackerel fillets at any time of year. This is especially the case with these fish since they are not subject to toughening or to denaturation of their proteins. It should be noted

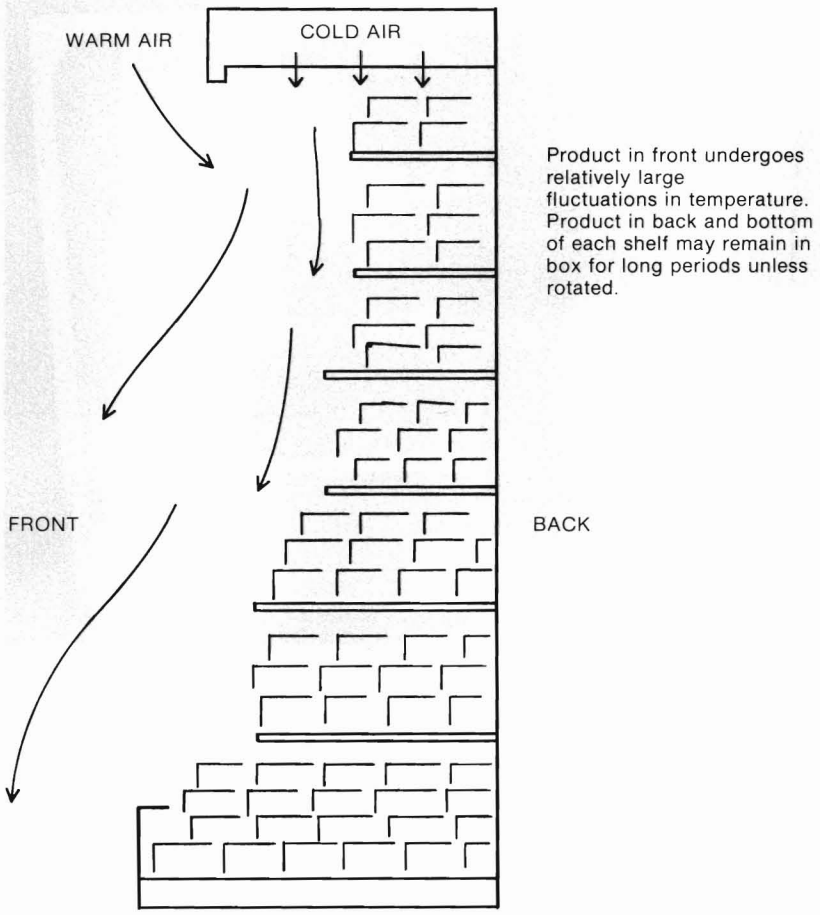


Figure 1.—Cross section of an open-shelf freezer display.

that even low-fat fish such as cod are subject to the development of rancidity during frozen storage.

The adequate packaging of marine foods is the responsibility of the packer, and until there is a change of attitude in this respect, there can be little improvement in the quality of frozen marine products.

After packing and freezing, fish and shellfish should be held at 0°F or below. Generally the packers of such foods have done a good job in this respect.

Transportation

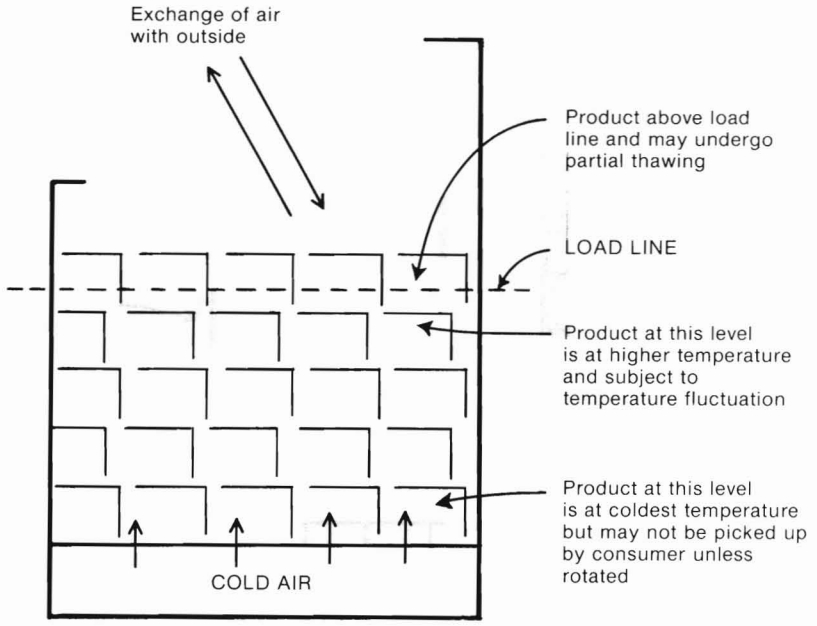
Frozen foods must be transported from the point where they were produced to the point where they will be retailed or consumed or to a warehouse for storage. In general, transportation procedures for these products have not been and are not good. Too often trucks with no refrigeration are used for moving these products over short or even somewhat longer distances and, for long hauls, inadequate refrigeration is used and some truck drivers have been known to sometimes shut off the refrigeration system even when it was available. Thus, oftentimes the already frozen load is depended upon to provide the refrigeration within the carrier. It has been stated that "frozen foods have a memory," which means that any time they have been held, even for short periods, above suitably low temperatures, and especially above 0°F, the produce undergoes some deterioration and that this deterioration will result in a shortening of the frozen shelf life of the food. There is no reason why a temperature recorder could not be placed in trucks transporting frozen foods in order to check that the transporters of these foods maintain temperatures of 0°F or below in all parts of the load during shipment. This has been done in some instances. Since, except for fast-food chains, most retailers of frozen foods will not accept the responsibility of determining whether adequately low temperatures are maintained during the shipment of frozen products, it would appear to be up to the producer to require strict transporting specifications and to use only those transporters who follow the required handling procedures.

Handling at Retail

In all probability frozen foods deteriorate to the greatest extent at the retail outlet because of inadequate speed of handling upon arrival, display at temperatures which are not low enough, and neglect of effective rotation of product, i.e., the first item to be offered for sale should be the first item sold. When a carrier arrives at its destination, the driver is eager to unload and move on. However, this should only be done when there is enough help available to promptly move the product to frozen storage. This policy would prevent the storage of frozen foods on outside platforms or inside rooms where the ambient temperatures may be quite high. Storage rooms at retail stores should be held at 0°F or below. In Massachusetts (and possibly other states), it is illegal to hold frozen foods at temperatures higher than 0°F. This law is important for insuring the maintenance of good quality and avoiding any possibility of the development of microbial toxins. Accordingly, a similar law, strictly enforced in all states, would greatly enhance the quality of frozen fish and fish products.

There are three methods of displaying frozen foods at retail, and two of these are inadequate as well as wasteful. Probably the worst of these is the open-shelf unit (Fig. 1). This type of

Figure 2.—Cross section of open-top freezer.



freezer display case also wastes energy since much of the refrigerated air escapes. It also wastes the products that eventually spoil in it. Generally, it is not operated properly, resulting in high temperatures around the product and, in some cases, even defrosting some of the food, and it does not provide for the handling of the food on a "first in, first out" basis.

The open top frozen food display case (Fig. 2) probably provides better temperature for frozen foods than the open-shelf type of frozen food cabinet since cold air is heavier than warm air and tends not to leave the box, but in this instance the frozen product may be piled above the load line, resulting in exposure to high temperatures. Again, there is a defrosting problem with such display cases, and no provision is made for moving the food on a "first in, first out" basis. Some of these cabinets have sliding glass covers, but these are often left open by customers.

Probably the best display freezer in current use for frozen foods is the enclosed shelf-type case having glass-paneled doors (Fig. 3). This type of freezer probably provides fairly good temperatures for frozen foods even though individuals sometimes open the doors and look for what they wish to purchase for several minutes at a time, causing cold air to escape. But even in this type of case there is no provision for handling the product on a "first in, first out" basis. Also, as with the other two types of display cases, both their design and their mode of operation make it impossible to maintain the products at a uniform and relatively constant temperature. Thus, the product is exposed to a broad range of temperatures, depending on its location within the box, and to a large fluctuation of temperatures because of the design which has either a large open side or a large side that is open frequently. Both a broad range of temperatures and fluctuating temperatures contribute to deterioration of quality. These units

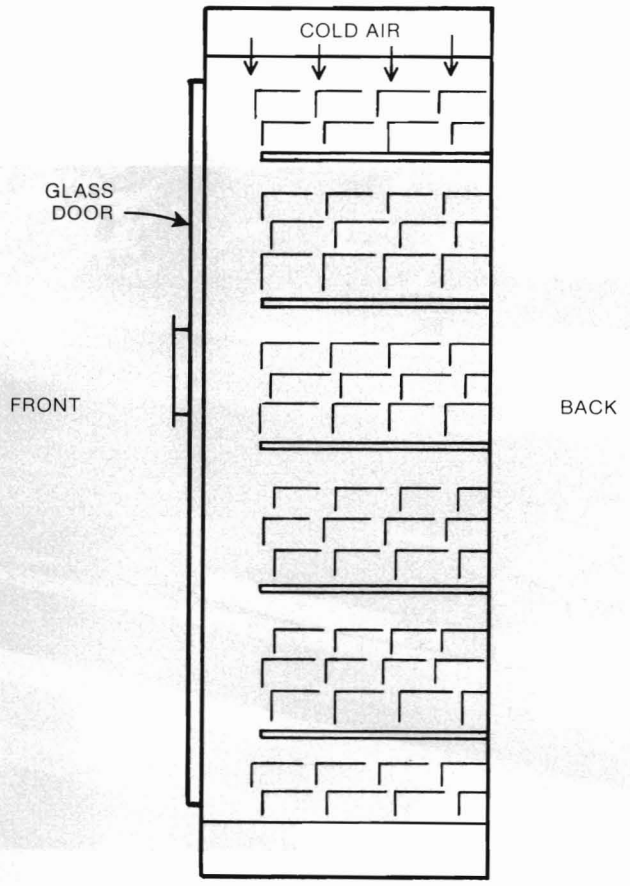


Figure 3.—Cross section of enclosed upright freezer case.

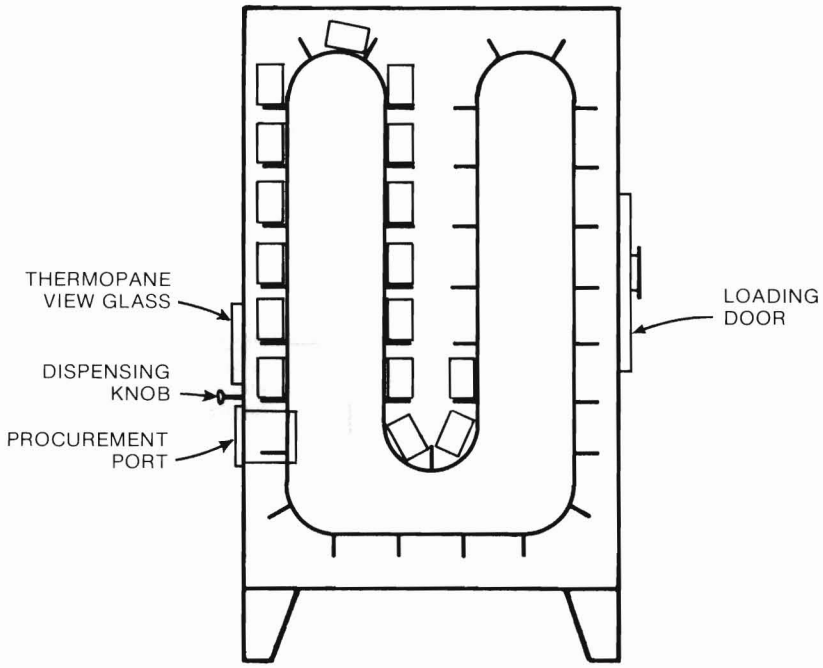


Figure 4.—Conceptual design of frozen seafood dispenser.

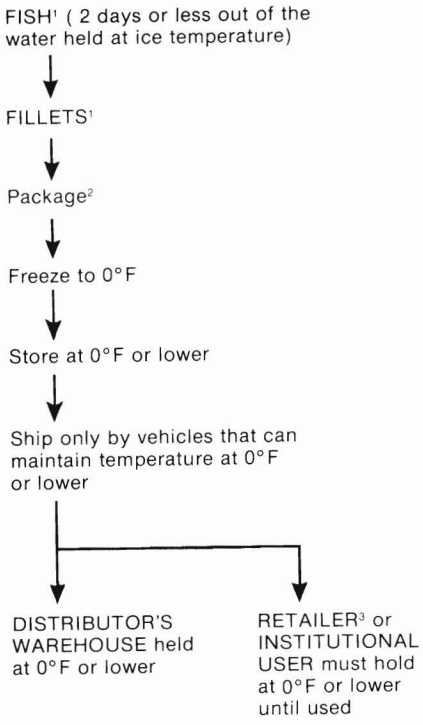
U.S. Grade A fish fillets at the supermarket.

are also plagued with frequent frosting due to the continuing condensing of moisture present in the ambient air which enters the box.

Consideration of these problems has led to the concept of a design which employs principles used in vending machines (Fig. 4). Vending machines are entirely closed, except for small openings that permit the discharge of items therefrom, in single units. This design radically minimizes the exchange of cold air in the machine with the warm ambient air. It further permits an opportunity to effectively insulate the contents from the entry of ambient heat. A thermopane window can be used to permit the customer to view the product.

Vending machines also employ a unit conveyor system that automatically dispenses the first unit loaded into the machine. Thus, for the first time the "first in, first out" principle is relatively assured and the undesirable probability that any of the product might remain in storage for excessively long periods is virtually eliminated. It eliminates problems created by pull-dates due to the customer's selection of those units that have the longest shelf life remaining. This type of freezer case has other advantages which include the virtual elimination of frost accumulation within it and on elements of its refrigeration system because of the inability of moisture-laden ambient air to enter it. Also, since the product will be packaged in gas-impermeable containers, there can be no migration of moisture from the product to any part of the display case.

As with any innovative change in a process, disadvantages of such a display case may emerge when it is tested under commercial conditions. One possibility is that a customer may dispense a package, not like it for some reason, dispense a second or even a third one before being satisfied, leaving the first or second package at ambient temperature, having no way to return it to the machine's conveyor system. This probability can be lowered or perhaps eliminated by insuring uniform apearance and weight among packages. Nevertheless, the advantages to be derived,

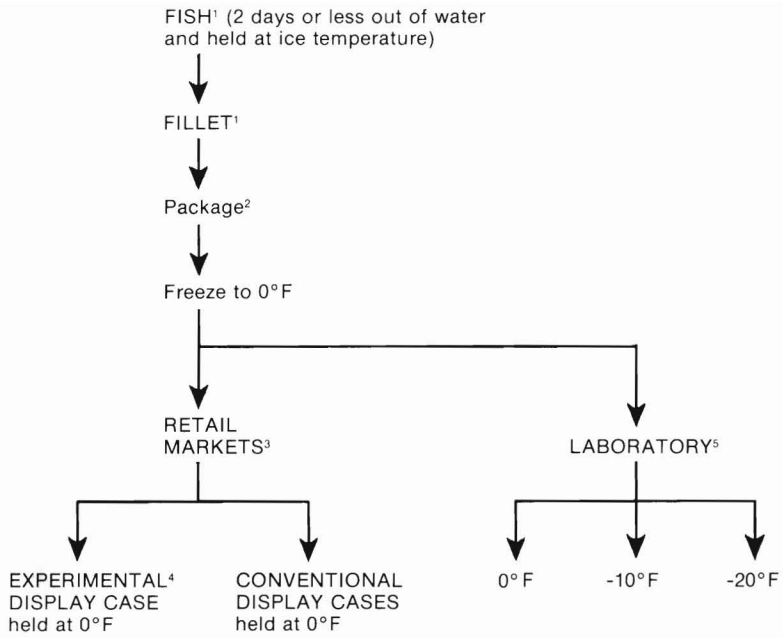


[1]Inspect for quality—use only U.S. Grade A—and during processing

[2]Use gas impermeable and water-vapor impermeable containers

[3]Retailer and other users should be checked for compliance with specified guidelines on handling

Figure 5.—A handling sequence to insure the quality of frozen fish fillets at U.S. Grade A at time of use.



[1]USDC inspected, only U.S. Grade A product to be used

[2]Package to be specified by collaborating packaging engineer

[3]Marketing and economic analysis by collaborating Sea Grant Universities

[4]Experimental display case to be built by collaborating manufacturer Energy savings and quality protection characteristics of prototype to be compared with those of conventional cases

[5]Storage study in laboratory to determine effect of storage temperature on quality, shelf life, and economics of frozen stored fillets

Figure 6.—Experimental design to test recommended procedures.

especially in conserving energy and preventing spoilage, are expected to outweigh the disadvantages.

Recommended Handling Procedure

Some of the recommendations made herein derive simply from the application of a common sense attitude that should be applied in the handling of all foods. Some of the recommendations may meet with some reluctance, especially where expensive packaging and the use of more refrigeration implies higher costs. However, it is anticipated that the added cost will not be very high and it has already been demonstrated that consumers are prepared to pay the slightly higher price in return for high-quality products. A summary of these recommendations for handling fish fillets is shown in the flow diagram in Figure 5.

An experiment could be designed to demonstrate the ability to maintain the high quality of fish fillets and the technical feasibility of the recommendations. The economics of the recommended procedures can be measured, and these would include a measure of efficacies of specified packaging and the frozen fillet storage/dispenser case shown in Figure 4. A flow diagram of the experimental procedure is shown in Figure 6.

Literature Cited

Anonymous. 1961. Frozen fried fish sticks. Cons. Rep. 26:80-83.

Dassow, J. A. 1976. Handling fresh fish, *In* M. E. Stansby (editor), Industrial fishery technology, p. 269-282. Robert E. Krieger Publ. Co., Huntington, N.Y.

Hulme, S. E. and D. W. Baker. 1977. Chilled seawater system for bulkholding sea herring. Mar. Fish. Rev. 39(3):4-9.

Ronsivalli, L. J., C. Gorga, J. D. Kaylor, and J. H. Carver. 1978. A concept for assuring the quality of seafoods to consumers. Mar. Fish. Rev. 40(1):1-4.